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of:

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for:

Fuel Container Having Contiguous Unbonded Polyacetal/Polyolefin Layers

FUEL CONTAINER HAVING CONTIGUOUS
UNBONDED POLYACETAL/POLYOLEFIN LAYERS

5 Technical Field

 The present invention relates to fuel containers such as fuel tanks and the like having a capacity of 5 gallons or less and including an outer layer of a polyolefin resin in intimate unbonded contact with an inner layer of a polyacetal resin. The polyacetal inner layer serves as a barrier layer while the polyolefin
10 provides impact resistance.

Background of the Invention

 Multilayer containers and other articles have numerous applications in industry, particularly for packaging applications. Kirk-Othmer Encyclopedia of
15 Chemical Technology, Third edition, Volume 10, page 216 (1980), Wiley-Interscience Publication, John Wiley & Sons, New York, details generally the materials and processes required for making such articles as well as their applications. Generally, such articles are prepared by co-processing individual polymers in injection or extrusion operations or by laminating individually formed
20 layers together or by a combination of these processes. Co-processing refers to forming and/or subsequently processing at least two layers of polymeric material, each layer comprising a different polymeric material. Common polymers used in these applications include polyethylene, polypropylene, ethylene-vinyl acetate copolymer, ethylene-vinyl alcohol copolymer, ethylene-methyl acrylate
25 copolymer, polyvinyl chloride, polyvinylidene chloride, polyacetal, polyamide, polyester, polycarbonate, polystyrene, acrylonitrile copolymers and the like. Desired properties in the laminates, containers, films, sheets and the like depend on the intended applications but generally include good mechanical properties such as tensile and impact strengths, processability, tear resistance, gas barrier
30 properties, moisture barrier properties, optical properties, thermal and dimensional stability.

Many methods of forming useful articles from combinations of polymers require that all components of the combination be stretched, expanded or extended in one or more directions, or deformed in some other way, such as by folding, creasing and the like. This stretching, extending or other deformation may be carried out concurrently with the process of forming the laminate or individual layers from the melt or may be part of a subsequent forming operation. Such methods of forming include but are not limited to, uniaxial and biaxial stretching of extruded films, thermoforming of multilayer laminates, blowing of extruded or injection-molded tubes, stretch blow molding of preforms or parisons, creasing or folding of laminates to form boxes, twisting of films to form a wrapper and the like.

Combining layers of different polymers takes advantage of the different properties which may be available in the different polymer layers. Such processes typically require the use of specialized equipment or materials such as adhesives, adhesive "tie" layers and the like.

U.S. Patent Application No. 2001/0034407 to *Ariyasu et al.* discloses a multilayered thermoplastic resin structure consisting of an outer layer of polyethylene bonded to an inner layer of polyacetal through an intermediate "tie" layer composed of a melt blend of the two polymers.

There is disclosed in United States Patent No. 5,891,373 to *Hunter* a process of making a multi-layer tube. The tube, a multi-layer hydrocarbon vapor-impermeable tube is formed with a nylon outer layer and a vapor barrier inner layer such as ETFE, bonded together by two adhesive layers. The laminated tube is coextruded. The shear on the two adhesive layers is adjusted to bias the first adhesive layer towards the nylon outer layer and the second adhesive layer towards the ETFE barrier layer. This permits rapid coextrusion of the laminated tubing. Preferably, both adhesive layers are formed from a blend of nylon and ETFE. The ratio of nylon to ETFE can be adjusted so that the first adhesive layer

is preferentially adherent to the nylon layer, and the second adhesive layer is preferentially adherent to the ETFE layer, and both adhesive layers are adherent to each other.

5 United States Patent No. 5,476,120 to *Brumnhofner* teaches a layered tubing for use in a motor vehicle has a thick tubular inner layer formed of one or more sublayers of a synthetic resin having a predetermined hardness and a predetermined thickness and designed for use in a temperature range down to -
10 40°C, and a thin tubular outer crack-absorbing layer bonded externally to and surrounding the inner layer. The outer crack-absorbing layer is formed of a synthetic resin resistant to attack by lacquer solvent over the temperature range of the inner layer and having a hardness equal to at most 0.8 times the hardness of the inner layer and a thickness equal to at most 0.5 times the thickness of the inner layer. When lacquer is intentionally or accidentally applied to such tubing and the
15 tubing subsequently is flexed at extremely low temperatures, the lacquer will crack but the soft outer layer will not transmit the sudden change in shape and energy to the inner layer, causing a crack therein. Instead the soft outer layer will absorb the energy of the crack, leaving the underlying tubing intact and free of cracks.

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 A method of coextruding diverse materials as well as a device therefor is provided in United States Patent No. 4,405,547 to *Koch et al.* The coextrusion device can be used with conventional extruders and extrusion dies for forming layered products from at least two materials. It includes a manifold for receiving a
25 plurality of extruded feed materials, and a feedblock receiving the feed materials from the manifold. The feedblock includes first and second faces, entrance ports in the first face corresponding to the number of feed materials, channel means passing through the feedblock between the first and second faces directing each feed material into at least one separate profile, and exit ports in the second face
30 corresponding to the number of channel means, defining a first profile for each feed material. An adaptor is provided for receiving the first profiles from the

feedblock and includes first and second faces, an entrance port in the first face receiving said first profiles, an exit port in the second face corresponding to the entrance of the extrusion die and, a transition zone between the entrance and exit ports wherein the first profiles become contiguous and the overall configuration of the contiguous first profiles is adapted for receipt by the extrusion die. The device
5 can further include a reverser plate and alternate feedblocks having different exit ports.

JP-A-9-248851 discloses blow molded multilayer articles with an adhesive
10 resin layer of modified olefinic polymer sandwiched between a polyacetal resin layer and another thermoplastic resin layer, which enhances the bonding strength between both layers.

JP-A-2000-8981 discloses a method for integrating a polyethylene resin
15 piece with a polyacetal resin piece using an annular welding part of modified polyolefin resin having polar functional groups.

Despite advances in the coextrusion field, it is nevertheless difficult to find compatible diverse polymer components to make useful articles with a shaped
20 profile due to disparities in processing temperatures and the natural tendency of diverse materials to separate. Relative to injection molding processes, extrusion operations are difficult to control, particularly where a shaped profile is sought as opposed to film or sheet.

25 The shaped article of the present invention does not require layer-to-layer bonding.

Summary of the Invention

In one aspect of the invention there is provided a fuel container with an
30 inner barrier layer of polyacetal resin in intimate unbonded surface-to-surface contact with an outer polyolefin layer operative to absorb impact and distribute an

applied force, the two layers being optionally mechanically linked at one or more copular regions, but being otherwise capable of independent local displacement with respect to each other, wherein the fuel container has a capacity of about 5 gallons or less. Typically, the copular regions occupy less than 5% of the surface area between layers, and more preferably less than 1% of the surface area between the layers.

In another aspect, there is provided in accordance with the present invention a method of making a fuel container by way of blow-molding including

10 (i) preparing a moldable multilayer parison comprising an inner polyacetal resin layer in intimate and direct contact with an outer polyolefin layer thereof; and (ii) blow molding the parison into the container shape, including mechanically linking the polyacetal layer and the polyolefin layer at one or more copular regions, whereby the fuel container comprises an inner barrier layer of polyacetal resin in

15 intimate unbonded surface-to-surface contact with an outer polyolefin layer operative to absorb impact and distribute an applied force, the two layers being mechanically linked at one or more copular regions, but being otherwise capable of independent local displacement with respect to each other. The linking or copular regions may be the mold pinch areas or there may be provided shaped

20 features as hereinafter described and illustrated.

There is still further provided in accordance with the present invention a method of making a fuel container by co-injection molding comprising (i) injection molding a first resin layer in the shape of the container; and (ii) injection

25 molding a second resin layer in intimate and direct contact with the first layer in the shape of the container, such that there is provided an inner and outer layer mechanically linked at one or more copular regions; and wherein the inner layer is an inner barrier layer of polyacetal resin in intimate unbonded surface-to-surface contact with an outer polyolefin layer operative to absorb impact and distribute an

30 applied force, the two layers being mechanically linked at one or more copular

regions, but being otherwise capable of independent local displacement with respect to each other.

5 In typical embodiments, a coextruded article consists of a two layer thermoplastic fuel container wherein the inner polyacetal layer is a barrier to evaporative fuel components and the outer polyolefin layer, preferably HDPE, is an impact protective layer. The total thickness of the fuel container equals the thickness of the barrier layer plus the thickness of the protective layer.

10 A distinguishing feature of fuel containers of this invention is that the contiguous polyacetal and polyolefin layers are not bonded together with a tie layer as are conventionally processed multilayered automotive tanks. The only mechanical fixing of the layers occurs, for example, or the mold pinch of areas of the blow molded container or and the weld joint of an injection molded container.
15 This allows each material to be locally displaced independently during loading or impact. The outer layer distributes the impact loading over a larger area of the barrier layer. By design, the inner layer has enough strength to support itself in a very thin wall section and is free of attachment to the outer layer. During an impact, this inner layer has the ability to deform and absorb independently of the
20 outer layer.

Additionally, the inner layer can be made of a very low viscosity thermoplastic material that is relatively brittle as compared to the HDPE outer shell. Not having a bond between the layers allows them to act independently
25 when impacted or when other internal/external forces are applied. This allows the two layers to be much thicker than the normal multilayer container.

The foregoing and other features of the invention will become apparent from the discussion which follows.

Brief Description of Drawings

The invention is described in detail below with reference to the **Figures**, wherein like numerals designate similar parts and wherein:

5 **Figure 1** is a view in perspective of a fuel tank of the invention;

Figure 2 is a schematic view in cross-section of a continuously extruded and blow molded bi-layer polymer fuel container, the view being taken along line 2-2 in **Figure 1**;

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Figure 3 is a schematic view in cross-section of an injection molded and welded bi-layer polymer fuel container, the view being taken along line 3-3 in **Figure 1**; and

15 **Figure 4** is an expanded view of a weld joint and layer junction of the injection molded container shown in **Figure 3**.

Detailed Description of the Invention

20 The invention is described in detail below with reference to the Figures and various embodiments. Such description is for purposes of exemplification only and is not intended to be limitative of the invention which is defined in the appended claims.

25 Terminology is given its ordinary meaning as supplemented in this description.

 “Blow Molding” is the process of forming hollow products by expanding a hot plastic parison against the internal surfaces of a mold. Different blow molding processes offer different advantages, based on the material used, performance requirements, production quantity, and costs. In the continuous process, a stationary extruder plasticizes and pushes molten polymer through the head to

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form a continuous parison. For large part blow molding, accumulators are used to prevent sagging of the parison. Coextrusion blow molding makes it possible to combine materials with different properties to create a finished product most suitable for a particular application. This process can be used to fabricate products which contain several layers in their wall structures. The various parts of the structure can be optimized for the best balance between properties and cost.

“Co-Injection Molding” includes Double-Shot Molding, Insert Molding and Two-Shot Injection Molding.

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“Co-Extrusion” is the process of extruding two or more materials through a single die with two or more orifices arranged so that the extrudates merge and weld together into a laminar structure before chilling. Each material is fed to the die from a separate extruder, but the orifices may be arranged so that each extruder supplies two or more plies of the same material. Coextrusion can be employed in film blowing, free film extrusion, and extrusion coating processes. The advantage of coextrusion is that each ply of the laminate imparts a desired characteristic property, such as stiffness, heat-sealability, impermeability or resistance to some environment, all of which properties would be impossible to attain with any single material.

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“Double-Shot Molding” is a process for production of two-color or two-component parts by means of successive molding methods. The basic process includes the steps of injection molding one part, transferring this part to a second mold as an insert, and molding the second component against the first.

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“HDPE” refers to high density polyethylene. HDPE has virtually no branching and thus has stronger intermolecular forces and tensile strength. The lack of branching is ensured by the aid of a Ziegler-Natta catalyst, where the polymer chain actually grows out from the catalyst.

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“Insert Molding” refers to a process in which an article of metal or other material is incorporated in a plastic molding either by pressing it into the finished molding or by placing it in the cavity so that it becomes an integral part of the molding.

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“Multimanifold die” is a device that brings two or more melt streams together within the die prior to molding. This allows use of resins with a wider difference in viscosity since fewer changes in flow patterns are necessary.

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“Polyolefin” is a homopolymer or copolymer derived by polymerization of unsaturated hydrocarbons known as olefins. Polyethylene and polypropylene, as well as their copolymers, are important polyolefins.

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“Two Shot Injection Molding” is the process that involves first injecting one material into a single-cavity die just until the polymer has commenced to chill against the cold wall of the mold, then immediately injecting a second polymer to force the first polymer to the cavity extremity. The second polymer forms the interior of the molded article, the first material completely forming the outside of the article.

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“Unbonded” contact refers to the fact that contiguous layers may be displaced relative to one another without fracturing the layers.

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As noted above and described in detail below in connection with the drawings, the present invention is directed to small capacity fuel containers with an inner polyacetal layer contiguous with an outer polyolefin layer. The layers are unbonded in that they are not adhesively bound to each other so that local independent local movement of the layers is possible when the layers are in contact. That is, the layers are free to move with respect to each other except where mechanically linked. The polyacetal inner layer can be either a polyacetal copolymer resin or a polyacetal homopolymer resin. A preferred resin is

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CELCON[®] M450. The polyacetal inner layer can have a thickness from 0.005 to 0.1 inches, preferably from 0.01 to 0.08 inches and most preferably from 0.015 to 0.06 inches. A preferred polyolefin is high density polyethylene (HDPE). The HDPE outer layer can have a thickness of from 0.010 to 0.15 inches, preferably
5 from 0.030 to 0.125 inches and most preferably from 0.060 to 0.1 inches.

The polyacetal is generally supplied to a multimanifold co-extrusion die at a melt temperature of from about 350°F to about 375°F., typically the polyacetal is supplied to the die at a melt temperature of from about 355°F to about 365°F,
10 and the HDPE is supplied at a higher temperature.

The multilayer fuel container has a capacity of about 5 gallons or less, preferably 1 gallon or less, more preferably ½ gallon or less, most preferably 1 quart or less.

15 Polyoxymethylenes, i.e. polyacetals or oxymethylene polymers, useful in the present invention are generally characterized as having recurring oxymethylene units. Polyoxymethylenes are available as homo- and copolymers. The polymers of interest in the practice of this invention typically have a fairly
20 high content of oxymethylene units, i.e., generally predominantly oxymethylene repeat units. The polymers are well known in the art and have been reviewed extensively. Information on polyacetals may be found in "Acetal Resins," by *T.J. Dolce* and *John A. Grates*, Second Edition of Encyclopedia of Polymer Science and Engineering, John Wiley and Sons, New York, 1985, Volume 1, pp. 46-61.
25 Additional information on acetal polymers can be found in French Patent No. 1,221,148 as well as United States Patent Nos. 3,027,352, 2,072,069, 3,147,234, and 3,210,318. Polyoxymethylenes are commercially available from a number of manufacturers. Acetal homopolymers may be prepared by polymerizing anhydrous formaldehyde or trioxane, a cyclic trimer of formaldehyde. For
30 example, high molecular weight acetal polyoxymethylenes have been prepared by polymerizing trioxane in the presence of certain fluoride catalysts, such as for

example, antimony fluoride, and may also be prepared in high yields and at rapid reaction rates by the use of catalysts comprising boron fluoride coordination complexes with organic compounds, as described, for example, in United States Patent No. 2,989,506 to *Hudgin et al.*

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Typically, such homopolymers are stabilized against thermal degradation by end-capping with, for example, ester or ether groups, such as those derived from alkanoic anhydrides (e.g. acetic anhydride) or dialkyl ethers, (e.g. dimethyl ether). Methods of making end-capped acetal homopolymers are taught in United States Patent No. 10 2,998,409. Commonly, the homopolymers are end-capped by reacting the hemiacetal groups with acetic anhydride in the presence of sodium acetate catalyst. Polymeric acetals which have been found to be especially suitable for use in the composition of the present invention are oxymethylene copolymers having repeat 15 units which consist essentially of oxymethylene groups interspersed with oxy(higher alkylene) groups. Oxymethylene groups generally will constitute from about 85 to 99.9 percent of the recurring units in such copolymers. The oxy(higher alkylene) groups may be incorporated into the polymer by copolymerizing a cyclic ether or cyclic formal having at least two adjacent carbon 20 atoms in the ring in addition to trioxane. The cyclic ether or formal is incorporated by the breaking of an oxygen-to-carbon linkage. The preferred oxy(higher alkylene) group is oxyethylene. Oxyethylene may be incorporated into the polymer by copolymerization of ethylene oxide 1,3-dioxolane with trioxane.

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Typically, oxymethylene copolymers are stabilized after manufacture by degradation of unstable molecular ends of the polymer chains to a point where a relatively stable carbon-to-carbon linkage prevents further degradation of each end of the polymer chain. Such degradation of 30 unstable molecular ends is generally effected by hydrolysis, as disclosed, for example, in United States Patent No. 3,219,623 to *Berardinelli*.

Oxymethylene copolymers may also be stabilized by end-capping, again using techniques well known to those skilled in the art, as for example, by acetylation with acetic anhydride in the presence of a sodium acetate catalyst. The preferred POM polymers have melting points of at least 150°C.

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Crystalline polyacetal (oxymethylene) copolymers which are especially suitable for utilization with the polyolefins of this invention will usually possess a relatively high level of polymer crystallinity, i.e., about 60 to 80 percent or higher. These preferred oxymethylene copolymers have repeating units which consist essentially of oxymethylene groups interspersed with oxy(higher)alkylene groups. Oxymethylene groups generally will constitute from about 85 to about 99.9 percent of the recurring units in such crystalline copolymers. The oxy(higher)alkylene groups incorporated into the copolymer during copolymerization produce the copolymer by the opening of the ring of a cyclic ether or cyclic formal having at least two adjacent carbon atoms, i.e., by the breaking of an oxygen-to-carbon linkage. Crystalline copolymers of the desired structure may be prepared by polymerizing trioxane together with from about 0.1 to about 15 mol percent of a cyclic ether or cyclic formal having at least two adjacent carbon atoms, preferably in the presence of a catalyst such as a Lewis acid, ion pair catalysts, etc. The cyclic ether and cyclic formal preferred for use in preparing these preferred crystalline oxymethylene copolymers are ethylene oxide and 1,3-dioxolane, respectively. Among the other cyclic ethers and cyclic formals that may be employed are 1,3-dioxane, trimethylene oxide, 1,2-propylene oxide, 1,2-butylene oxide, 1,3-butylene oxide, 1,4-butanediol formal, and the like.

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Crystalline oxymethylene copolymers produced from the preferred cyclic ethers have a structure composed substantially of oxymethylene and oxy(lower)alkylene, preferably oxyethylene, groups, and are thermoplastic materials having a melting point of at least 150°C. They normally are millable or processable at temperatures ranging from 180°C to about 200°C, and have a number average molecular weight of at least 10,000 and an inherent viscosity of at

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least 1.0 (measured at about 25°C in a 0.2 wt. % solution in HFIP).

5 These crystalline oxymethylene copolymers preferably are stabilized to a substantial degree prior to being utilized with the elastomeric copolymers of this invention. This can be accomplished by degradation of unstable molecular ends of the polymer chains to a point where a relatively stable carbon-to-carbon linkage exists at each end of each chain. Such degradation may be effected by hydrolysis, as disclosed, for example, in United States Patent No. 3,219,623 to *Berardinelli*.

10 The crystalline oxymethylene copolymer may also be stabilized by end-capping, again using techniques well known to those skilled in the art. End-capping is preferably accomplished by acetylation with acetic anhydride in the presence of sodium acetate catalyst.

15 A particularly preferred class of crystalline oxymethylene copolymers is commercially available from Ticona LLC under the designation CELCON[®] acetal copolymer; which may be, for example, copolymers of trioxane with suitable comonomers and may have exemplary melt indices of 1.5, 2.5, 9.0 up to about 45.0 g/10 min. or more when tested in accordance with ASTM D1238-82.

20 Copolymers also include oxymethylene terpolymers having oxymethylene groups, oxy(higher)alkylene groups such as those described above, further including a different, third group interpolymerizable with oxymethylene and oxy(higher)alkylene groups. The third monomer may be a bifunctional compound such as diglycide. Examples of suitable bifunctional compounds include the
25 diglycidyl ethers of ethylene glycol; 1,4-butanediol; 1,3-butanediol; cyclobutane-1,3-diol; 1,2-propanediol; cyclohexane-1,4-diol and 2,2,4,4-tetramethyl-cyclobutane-1,3-diol, with butanediol diglycidyl ethers being perhaps most preferred. A particularly preferred acetal copolymer has a melt index of 45. Additives such as plasticizers, formaldehyde scavengers, mold lubricants,
30 antioxidants, fillers, colorants, reinforcing agents, light stabilizers and other stabilizers, pigments, and the like, can be used with the compositions of this

invention so long as such additives do not materially affect the desired interaction between the polyacetal and the thermoplastic elastomer. Suitable formaldehyde scavengers include cyanoguanidine, melamine and melamine derivatives and the like. Suitable mold lubricants include alkylene bisstearamides, long-chain amides, 5 waxes, oils, and polyether glycidides and the like.

Further details concerning suitable polyacetals are found in the following references:

10 United States Patent No. 3,639,192, issued February 1, 1972 to *Burg et al.*, discloses for use as adhesives copolymers of formaldehyde or trioxane with 1 to 60% by weight, preferably 1 to 30% by weight, of a cyclic ether, cyclic and/or linear acetal, e.g., 1,3-dioxolane, and/or an alkyl glycidyl formal, polyglycol diglycidyl ether or bis (alkane triol) triformal. Example 5 discloses a terpolymer 15 of 97.95 wt. % of trioxane, 2 wt. % of ethylene oxide, and 0.05 wt. % of 1,4-butanediol diglycidyl ether.

United States Patent No. 3,337,507, issued August 22, 1967 to *Gutweiler et al.*, teaches the formation of high molecular weight copolymers obtained by 20 polymerizing a mixture of trioxane and any of certain polyformals. Example 4 of the patent shows the use of a polyformal which is a clear highly viscous oil at 70°C. obtained by polymerizing a mixture of 1/3 mole of trioxane and 1 mole of dioxolane in the presence of p-nitrophenyl-diazonium fluoroborate as catalyst.

25 Japanese Kokai Sho 42-22065 of *Yamaguchi et al.*, published October 30, 1967, discloses copolymers of trioxane and an aperiodic ring compound, e.g., 1,3-dioxolane, prepared in liquid sulfur dioxide, and in Example 1 shows a copolymer of trioxane and 64 mol % of 1,3-dioxolane.

30 Useful polyolefins are high-density polyethylene (HDPE) and polypropylene. Other polyolefin homopolymers and copolymers of ethylene can

be utilized in the practice of this invention. Such other polyolefins include low-density polyethylene (LDPE), very low-density polyethylene (VLDPE), linear low-density polyethylene (LLDPE) and polybutylene (PB). However, these other polyolefins can be blended with other polyolefins such as polypropylene or high-density polyethylene (HDPE). The preferred polyolefin is HDPE.

The polymer layers are coextruded in some cases to form a bilayer structure, for example, by any suitable coextrusion method utilizing, for example, any of the devices noted in United States Patent Nos. 5,891,373 to *Hunter*; 5,476,120 to *Brumnhofner* and 4,405,547 to *Koch et al*; such methods are well known in the art. A combing block can be used, if so desired. In connection with a combining block, parallel openings within the block are fed from two or more extruders, one for each resin. The melts flow in laminar fashion through the die. Careful control of resin viscosity must be obtained to provide smooth flow, and the resins must be compatible in order to bond together properly. A more preferred method uses a multimanifold die to bring the melt streams together within the die. This allows use of resins with a wider difference in viscosity since fewer changes in flow patterns are necessary. The most common types of coextrusion are AB, ABA, or ABC where A is one polymer system, B is another (of the same polymer type or different), and C is a third polymer type.

In accordance with the present invention, a coextruded blow molded fuel tank 10 is produced as is shown schematically in **Figure 1**. Fuel tank 10 includes a neck 12 provided with threads 14 as well as a front 16, back 18 and sides 20, 22. Tank 10 may be fabricated by way of a blow molding process with a front panel 24 and a back panel 26 with a mold pinch line therebetween indicated at 28. When so constructed, the bilayer tank has a cross-section as indicated in **Figure 2** with an inner layer of polyacetal 30 and an outer layer 32 of HDPE. The layers are in contiguous surface-to-surface unbonded contact as shown and are mechanically linked by deformation at mold pinch line 28 to form linking or copular regions 34.

Alternatively, tank 10 is co-injection molded and welded at 40 as shown schematically in Figures 1, 3 and 4. The polymer layers may be extruded by the method known as two shot injection molding, described in U.S. Patent No. 4,460,534 to *Boehm et al.*, incorporated herein by reference. The process involves first injecting one material into a single cavity die just until the polymer has commenced to chill against the cold wall of the mold, then immediately injecting a second polymer to force the first polymer to the cavity extremity. The second polymer forms the interior of the molded article, the first material forming the outside of the article. The tank has inner polyacetal layer 30 outer HDPE layer 32. In this embodiment the tank has a lower half 42 and an upper half 44 joined by the welded area 40 shown in more detail in Figure 4. The welded area includes U-shaped portions 46 of the inner polyacetal layer imbedded in proximity with a thickened portion 48 of outer HDPE layer 34. The outer layer is melt seamed at 50 and the seam or copular region is indicated at 52.

Most preferably, the HDPE resin is provided to the multimanifold coextrusion die at a melt temperature of at least 100°F higher than the temperature that the polyacetal is supplied to the die. At least about 125°F higher or about 140°F higher is preferred. Typical polyacetal resins useful in connection with the invention have a melt-extrusion temperature window of from about 360°F to about 390°F and are supplied to the coextrusion die at a temperature of about 360°F.

Example

Utilizing a coextrusion apparatus with a multi-manifold die, Celcon M-450, available from Ticona LLC, Summit, N.J. and HDPE are coextruded and blow molded to produce a fuel container as shown in Figures 1 and 2.

The resin compositions are co-extruded under the following (approximate) conditions:

(A) Polyacetal Extrusion Conditions, Extruder 1

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Temperature Zone 1 340 F

Temperature Zone 2 350 F

Temperature Zone 3 360 F

Die 370 F

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(B) HDPE Extrusion Conditions, Extruder 2

Temperature Zone 1 320-350 F

Temperature Zone 2 330-390 F

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Temperature Zone 3 350-430 F

Die 370-450 F

The resins are formed into a parison upon exiting the die and the parison is blow molded into shape.

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While the invention has been described in detail in connection with numerous potential embodiments, modifications to those embodiments within the spirit and scope of the present invention, set forth in the appended claims, will be readily apparent to those of skill in the art.